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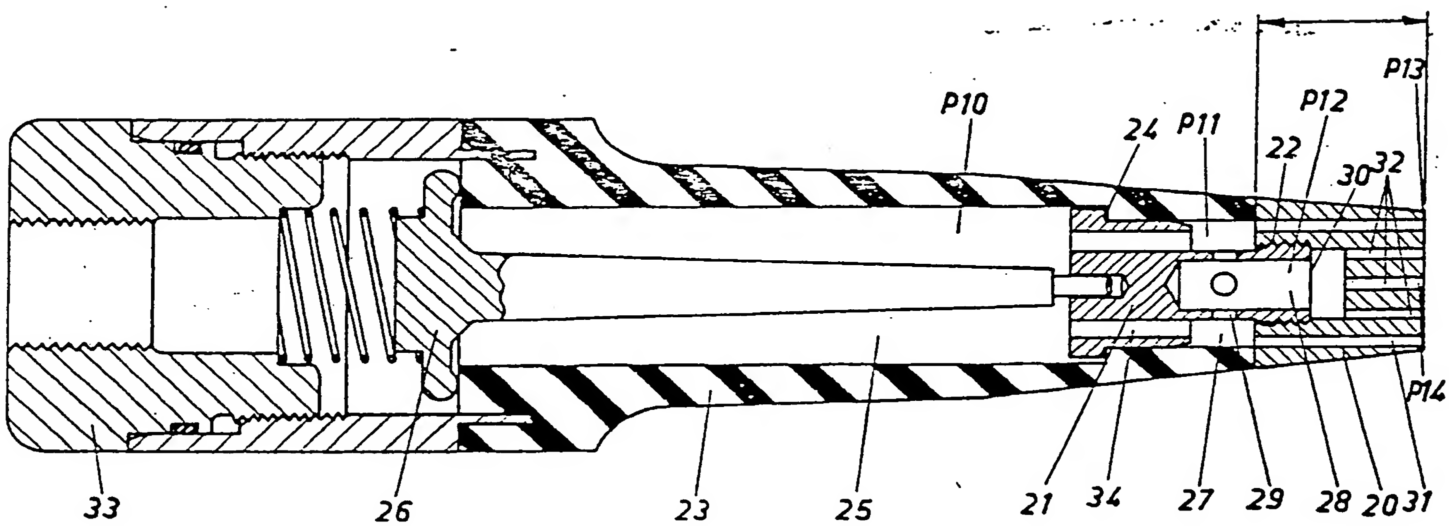

(57) Abstract

A multi-channel nozzle for a pressurized gas, which nozzle may be connected to various blowing tools of conventional design or directly to a distribution conduit. Peripheral primary flow channels (31) are arranged in the outlet of the nozzle, and inside these secondary flow channels (32) connected to a pressure regulating unit (21). This include at least one regulating passage (27, 29) and at least one reservoir chamber (28) which reduce the pressure of the gas which flow out of the central parts of the nozzle. This gives rise to a secondary flow which co-operates with a primary flow coming from the outer areas of the nozzle. The nozzle design provides a marked lower noise level and increased power density with the blowing power retained.

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A METHOD OF REDUCING NOISE GENERATION IN MULTI-CHANNEL NOZZLES AND A MULTI-CHANNEL NOZZLE FOR PERFORMING THE METHOD

The present invention refers to a method of reducing the noise generation in multi-channel nozzles for blowing devices for a pressurized gas and of providing an increased power concentration and a more concentrated flow. The invention also refers to a multi-channel nozzle for performing the method and comprising a plurality of substantially parallel outlet channels arranged peripherally in the nozzle.

Background of the invention

Nozzles of the above mentioned kind may be connected to various kinds of blowing tools of conventional design or, alternatively, directly to a distribution conduit. In the latter case, the necessary control means for the gas flow may be provided within the distribution conduit or, alternatively, at a central control unit. The blowing devices may be used for instance in turning and milling operation for cleaning by means of pressurized air or other gas. Furthermore, the blowing device may be used for cooling, heating, drying, ventilation etc.

The state of the art

For a better understanding of the invention and the theory behind it, this section refers to previously known nozzles designs illustrated in figures 1-3 of the accompanying drawings.

The velocity of discharge for a gas through a tubular nozzle according to figure 1 is dependent upon the pressure ratio P_1/P_2 where P_1 is the gas pressure in the through-flow channel 2 of the nozzle 1 and P_2 is the pressure immediately outside the channel mouth 3. If this ratio P_1/P_2 is larger

than or substantially equal to 1.89, critical flow will be obtained. Unless the outlet 3 is formed as a Laval nozzle, no increased velocity will be obtained if the pressure ratio is increased further. If the ambient pressure P_3 outside the nozzle is approxiamately equal to atmospheric pressure, critical flow will normally be obtained if the pressure P_1 is greater than 5-6 bar, i.e. the pressure P_2 will normally be greater than atmospheric pressure. This is due to the fact that the outflowing gas will draw some of the surrounding atmospheric air along with it, which reduces the velocity of the gas blow, whereupon a certain portion of the dynamic pressure of the gas blow will be transformed into static pressure. If the outlet does not communicate with the atmosphere, critical flow will be obtained at a substantially lower pressure than P_1.

When the pressure ratio is critical, the temperature T_1 in the through-flow channel 1 will be lowered downstreams of the outlet to a temperature T_2 which, if the gas is air and the isotropic exponential equals 1.4, will be equal 0.833 times T_1. The density of the air will thereby be reduced by a factor of 0.633. The relation between pressures and temperatures is given by the expression:

$$P_1/(T_1 \times \rho_1) = P_2/(T_2 \times \rho_2)$$

where ρ is the density of the gas.

When a gas, for instance air, is discharged from an outlet there will be formed a core jet 4 and a mixing zone 5. In the down stream direction of the flow the air- jet will expand corresponding to the angle V, which normally is 6-8^{o}. One reason for such expansion is that the moving air-jet pulls surrounding air along with it. The air-jet increases in mass but looses velocity. The decrease will be largest in the outermost layer of the air-jet and least within the center portions of the jet. The pressure transformation from dynamic pressure into static pressure will thus be largest within outerareas of the jet.

The non-uniformity of the locally and periodically varying pressure differencies will increase with increased cross-sectional area. It is of advantage, for instance from the point of view of noice generation, to divide a larger flow into several smaller flows well separated from one another, see fig. 2 and 3. This will also cause the periodicity of the pressure pulsations to be displaced to higher frequencies, i.e. the noice will be of higher frequency. With sufficiently narrow through-channels 6 the dominating pressure pulsations downstream of the outlet 3 may be displaced to frequencies in exess of 20.000 Hz, i.e. to frequencies which are inaudable to humans.

A multi-channel nozzle according to figures 2 and 3 will provide a high blowing power at a low air consumption. However, the blowing function and the power concentration will be limited, especially when the nozzle is designed for obtaining higher blowing forces, for instance when the nozzle is used as a so called blow gun. In such cases, a larger number of outlet channels 6 are required than is shown in fig. 3. If the optimum channel spacing is thereby maintained in order to obtain a noiceless and efficient blowing, the air-jet obtained as the sum of the part jets will have unacceptable extension at right angles to the direction of the flow, which means that, apart from the area hit by the jet being unreasonably large, the blowing power per surface unit will be too low.

Research has shown that, as far as the blowing function is concerned, a concentrated air flow will normally not entail any drawbacks. As an example, a conventional tubular nozzle has very good blowing properties. The advantage of a concentrated air stream is especially noticeable in blowing dirt from holes, grooves, etc.

In a multi-channel nozzle of practical dimensions the noice reducing properties are limited by the fact that the separate air-streams from the outlet channels 6 will combine to form a single flow 8 at a short distance downstreams of the plane 7 of the mouth, see fig. 2. Despite the fact that each part stream 9 has lost velocitiy, i.e. due to a high degree of co-ejecting, powerful turbulences will occur within the newly formed composite flow 8. This will occur - but to a reduced degree - in a similar manner as in the air-jet from the tubular nozzle according to fig. 1. The degree of turburlency will be larger the smaller the distance is between the outlet channels 6.

The object of the invention

The object of the present invention is to provide a multi-channel nozzle with reduced turbulency and thereby reduced noice generation for the composite flow in the mixing zone outside the mouth. The invention further aims at providing a higher power concentration and a more concentrated flow. Nozzles according to the invention, the functions of which have been tested, have considerably lower noice levels than admittedly low-noice multi-channel nozzles. As an example, with the blowing power retained, the noice level may be reduced to more than one half, i.e. the noice reduction corresponds to at least 3 dB (A). According to the invention this has been attained by the method according to claim 1 and a nozzle structure having the characteristics stated in claims 2-4

Description of the figures

Fig. 1 is a longitudinal section through a conventional tubular nozzle and illustrates the distribution shape of the gas-jet downstreams of a circular outlet.
Fig. 2 is a longitudinal section through a previously known multi-channel nozzle showing the distribution shape of the gas-jets.

Fig. 3 is an end view of the nozzle according to fig. 2.
Fig. 4 is a longitudinal section through a nozzle according to the invention connected to a blowing tool.
Fig. 5 is an end view of the nozzle according to fig. 4.
Fig. 6, 8 and 10 illustrate in section other embodiments of nozzles according to the invention, and
Fig. 7, 9 and 11 are end views of nozzles according to fig. 6, 8 and 10.

Description of embodiments

A first embodiment of a nozzle according to the invention is illustrated in fig. 4 and 5. The nozzle is composed of the outlet portion 20 and the pressure regulating unit 21. The two parts may be interconnected by means of a screw connection 22, but the connection may naturally be effected by means of a press fit, welding or gluing. The nozzle is intended to be connected to a base part 23. By means of the screw connection 22 the two nozzle parts 20 and 21 are secured against a shoulder 24 and one end surface of the base part 23, respectively. The base part 23 may be connected directly to the compressed air conduit or it may constitute a complete blowing tool. The base part may then be made of rubber or other elastic material.

The pressure regulating unit 21 is provided with feeder channels 34 which connect the inner space 25 of the base part 23 with a distribution chamber 27. The pressure regulating unit it also provided with an internal reservoar chamber 28 provided with at least one-flow opening 29 through which the two chambers 27 and 28 communicate with each other. The reservoar chamber 28 is further made with an opening 30 towards the secondary flow channels 32 of the outlet part said channels 32 being provided inside of the primary flow channels 21 which are arranged periferally in a circle and communicate directly with the distribution chamber.

When a pressuzied gas is supplied to the valve housing 33 and a valve 26 provided therein is opened by tilting the elastic base part 23 whereupon the valve body 26 will change its position relative to the valve seat, there will be obtained a gas pressure P10 in the space 25, substantially the same gas pressure P11 in the distribution chamber 27 and lower gas pressure P12 in the reservoar chamber 28. The secondary flow channels 32 are communicating directly with the reservoar chamber 28 and thus with the feeding pressure P12.

At the outlets of the primary flow channels 21 an outlet pressure P13 will be obtained, and at the outlet of the secondary flow channels 32 an outlet pressure P14 will be obtained. The feeder channels 34 in the pressure regulating 21 should have a total through-flow area which is larger than the total through-flow area of the primary flow channels 21 and the secondary flow channels 22.

The gas discharged from the nozzle via the primary flow channels 31 and the gas discharged through the secondary flow channels 32 will thus be substantially different as concerns the state of the gas. Among other things, the primary flow when discharged from the outlet part 20 will have an outlet pressure P13 which is higher than the outlet pressure P14 of the secondary flow.

It should be noted that the noice reductions obtained with the nozzle according to the invention are not primarily based upon a regulation of the mass flow amount of the primary flow in comparison with the secondary flow. Tests with considerably differencies in the mass flow of the secondary flow have shown noice reductions only upon the fulfilment of certain other conditions in accordance with the invention, which conditions will be described more closely here below.

When the secondary flow with lower pressure and density cooperates with the primary flow to form a composite flow 8 according to fig. 2, lower turbulence will be obtained within and around the composite flow. This will cause less noice genaration and lower losses of momentum of the flow.

In order to obtain a sufficient pressure difference between the primary flow and the secondary flow, the least total area of the trough flow opening 29 should be less than 1.3 times, preferably less than 0.8 times the total area at the secondary flow channels 32, so that the ratio between the total pressures P14 and P13 is less than 0.87, preferably less than 0.73. Further, some part of the reservoar chamber 28 should have a through-flow area which is more than 1.5 times larger, preferably more than 5 times larger than the total area of the through-flow opening 29, so that kinetic energy generated therein will substantially be lost.

Within the reservoar chamber 28 a gas temperature will be obtained which substantially corresponds to the gas temperature within the chamber 27. The rate of flow at the outlet of the outlet part 20 obtained through the expansion of the gas will thus be substantially the same for the primary and the secondary flows.

When, in this manner, the rate of flow for the primary and secondary flows at their discharge from their respective outlets may be made substantially equal, the secondary flow will receive, apart from a lower total pressure, also a comparatively high dynamic pressure. The static pressure at the discharge of the secondary flow from the secondary flow channel 32 will therefore be lower than the static pressure of the primary flow at its outlet from the primary flow channel 31. Related to the mass flow amount the secondary flow will give a higher degree of co-ejection than the primary flow.

According to the invention the primary flow is always composed of two or more part flows. The outlet channels 31, of which there will thus always be two or more, may be substantially circular, and the through-flow area have a largest cross sectional measure D which should be less than 2 millimetres, preferably less than 1.3 millimetres, in order to minimize negative effects such as described in connection whith fig. 2.

The primary flow channels 31 may also with advantage be in the form of two or more slot channel 35 according to fig. 6 and 7. The largest slot S should be less than 2 millimetres, preferably less than 1 millimetre. The length L of the primary flow channels should be greater than 3 times, but preferably greater than 5 times the cross sectional measure D and the slot measure S, respectively. The regulating passage 29 does not necessarily have to communicate directly wiht the chamber 27, but instead communication may be directly with the space 25 - for instance in accordance with what is shown in fig. 6.

The secondary flow does not necessarily have to composed of two or several part flow, but may have only one central outlet within the outlet part 20. This is true even for such cases where the secondary flow before the outlet passes through a low pressure chamber 36 connected in series with the reservoar chamber 28, as illustrated in fig. 8. In said low pressure chamber there is provided a choke device 37 which may have one or several thorugh-flow channels 38. The latter should have a least total through-flow area which is less than 1.3 times, preferably less than 0.8 times the total through-flow area of the secondary flow channels 32.

The embodiment according to fig. 8 and 9 with a low pressure chamber 36 connected in series may advantageously, but not necessarily, be included in a nozzle which has secondary flow channel 32 arranged in two or several circles (as shown in fig. 10 and 11) which may be independently design

to give different gas state of the gas discharged from the outlet part 20. Thus, with this embodiment the discharged gas may be given three different gas states, whereby is provided a less turbulent outflow for obtaining a lower noice level while retaining the blowing power.

The nozzle has been tested and has thereby been compared with the conditions in most of the commercially available nozzle types. The comparison has included i.e. the noice limiting nozzles design according to Swedish patent application No. 7910235-6 and the US patent specification 3984054. In all cases it was found that a nozzle design according to the invention, at equal blowing power at the normally used feeding pressures of 5-9 bar, gives a lower noice level, a higher power concentration, and a higher, or at least equal, efficieny.

The invention is not limited to the embodiment shown and described but may be varied in various other ways within the scope of the claims.

CLAIMS

1. A method of reducing the noice generation in multi-channel nozzles or blow devices for a pressurized gas and of providing a higher power concentration and a more concentrated flow, the gas flow being devided into a number of peripheral primary flows and secondary flows disposed within said primary flows,

c h a r a c t e r i z e d i n t h a t,

the secondary flow at its expanding exit from the secondary flow passage (32), by means of at least one pressure reducing device (28, 36), is given a substantially lower static pressure than the corresponding pressure of the primary flow at its expanding exit from the primary flow passage(31), so that, related to the massflow amount, the secondary flow will give a higher degree of co-ejection in comparison with the co-ejection of the outer surrounding gas caused by the primary flow.

2. A multi-channel nozzle for performing the method according to claim 1 and comprising a plurality of substantially parallel out-flow channels arranged peripherally in the nozzle, at least one secondary flow channel (32) being provided inside of the peripherally arranged out-flow channels (31) for the primary flow,

c h a r a c t e r i z e d i n t h a t

the secondary flow channel (32) is connected to the feeding pressure (P10, P11) of the primary gas flow by means of a channel system delimited against the surrounding atmosphere and comprising at least one pressure reducing device (28) which is designed, in co-operation with the secondary flow channel (32) to lower the total pressure of the secondary gas flow at its expanding exit from the outlet part (20) by at least 13%-units relative to the total pressure of the primary gas flow at its expanding exit from the outlet part (20).

3. A multi-channel nozzle according to claim 2, characterized in that the pressure reducing device (28) provided for the delimited channel system between the primary and secondary gas sides is constituted by a reservoar chamber communicating with the secondary flow channel or channels (32), said reservoar chamber being connected to the primary gas side via at least one through-flow opening (29), and that the total area of the through-flow opening or openings (29) is less than 1.3 times, preferably less than 0.8 times the total area of the secondary flow channels.

4. A multi-channel nozzle according to claim 3, characterized in that the reservoar chamber (28) for the delimited channel system between the primary and secondary sides is comprised of at least one passage (30) the area of which is at least 1.5 times larger, preferably 5 times larger than the area of the through-flow opening (29).

FIG 1

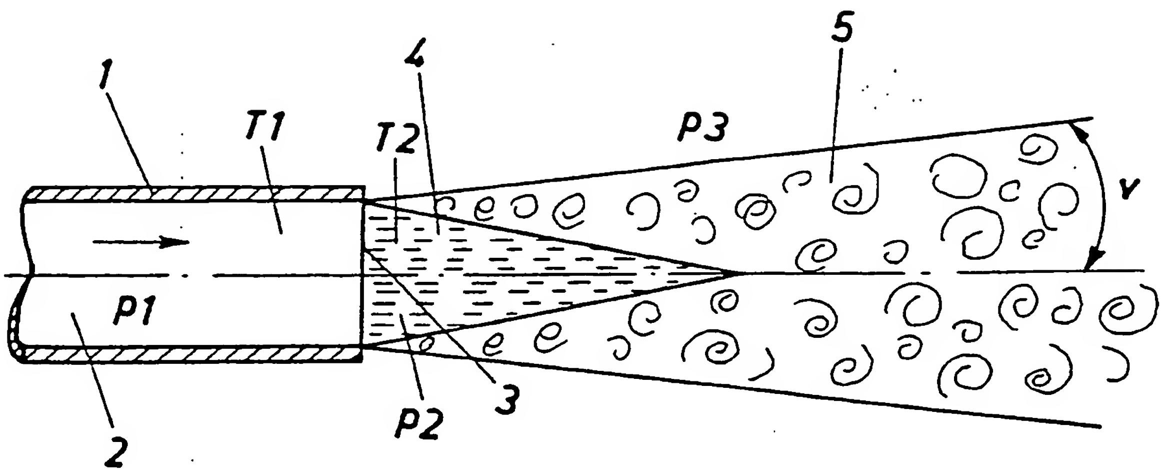


FIG 2

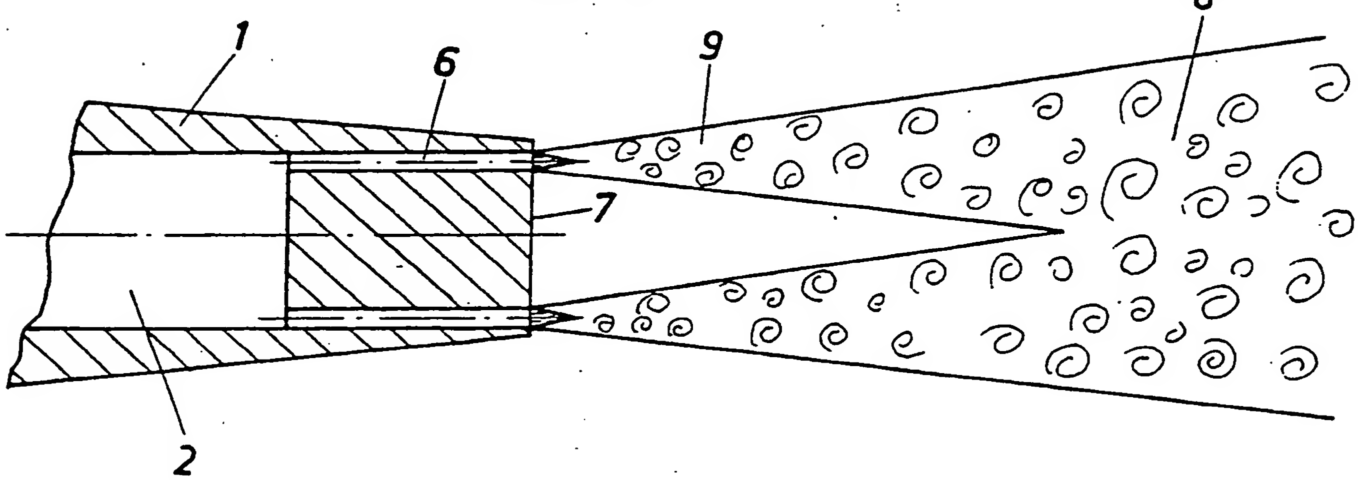
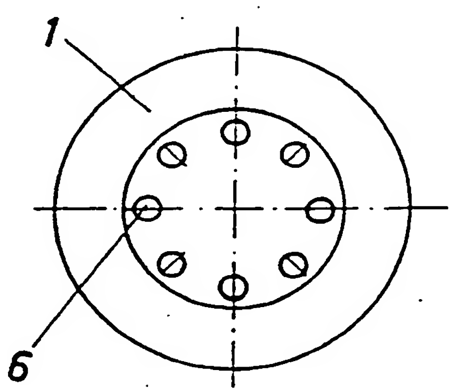


FIG 3



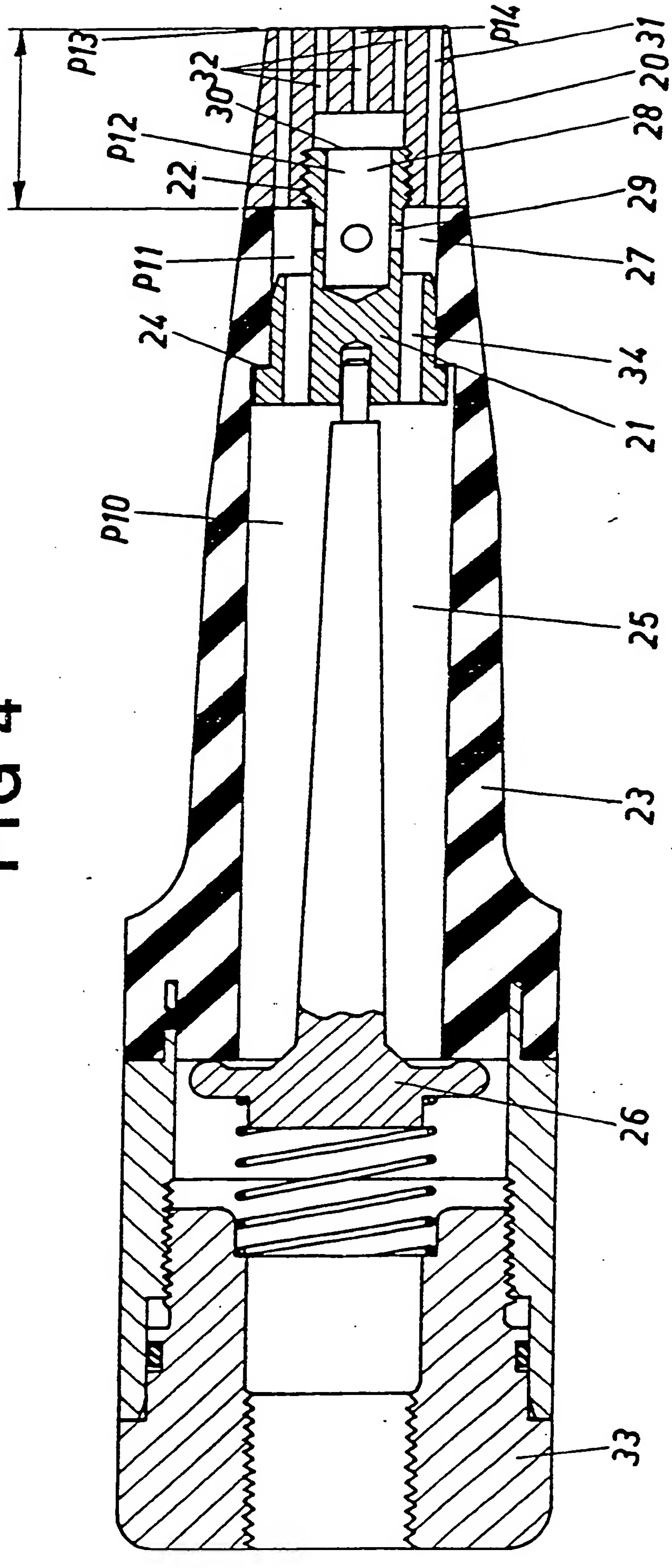


FIG 4

FIG 5

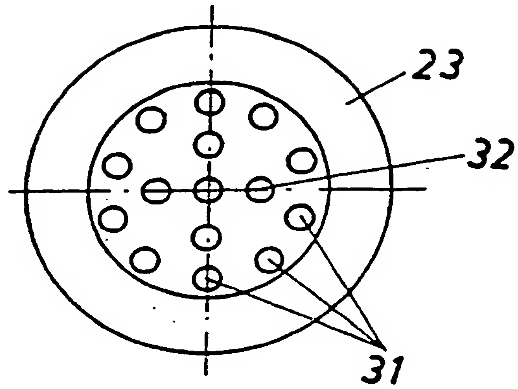


FIG 6

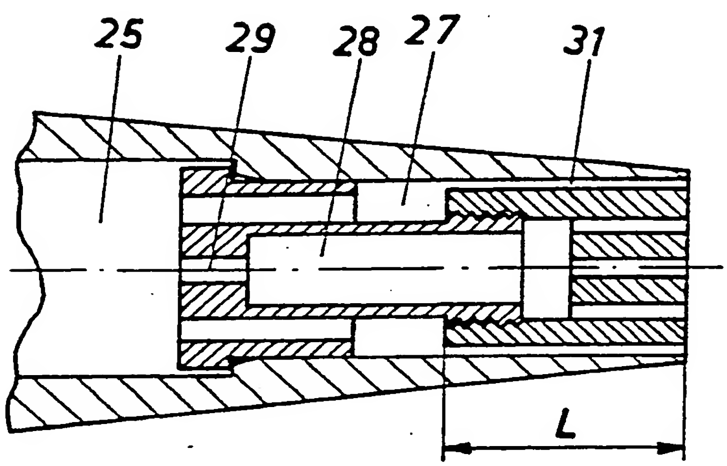


FIG 7

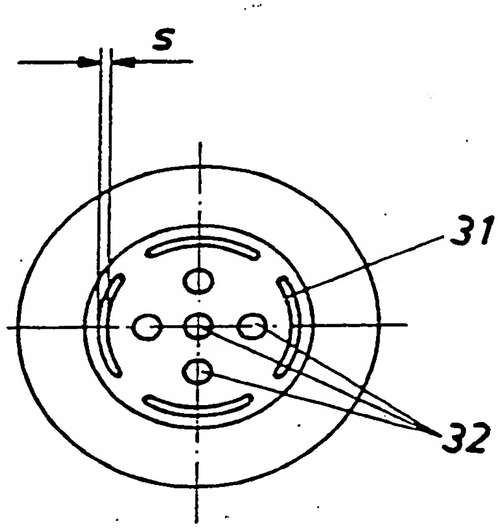


FIG 8

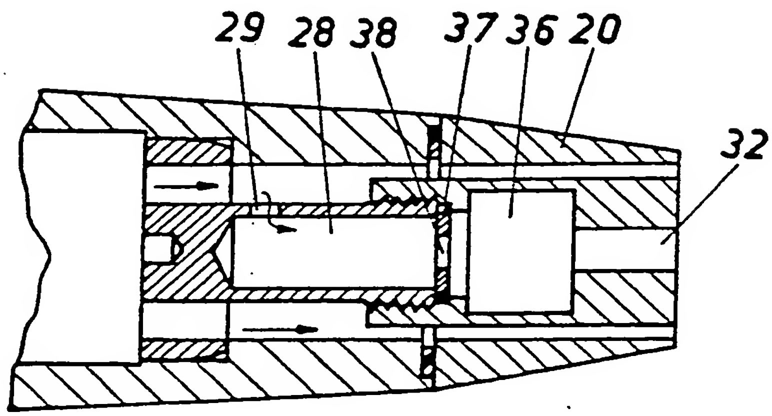


FIG 9

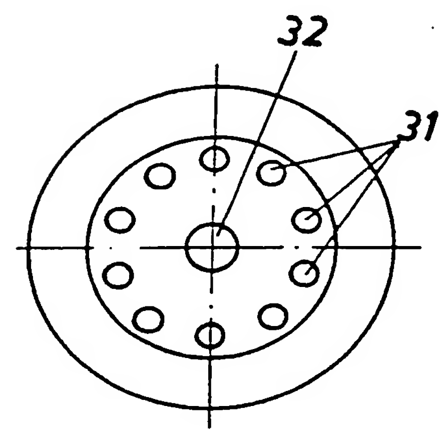


FIG 10

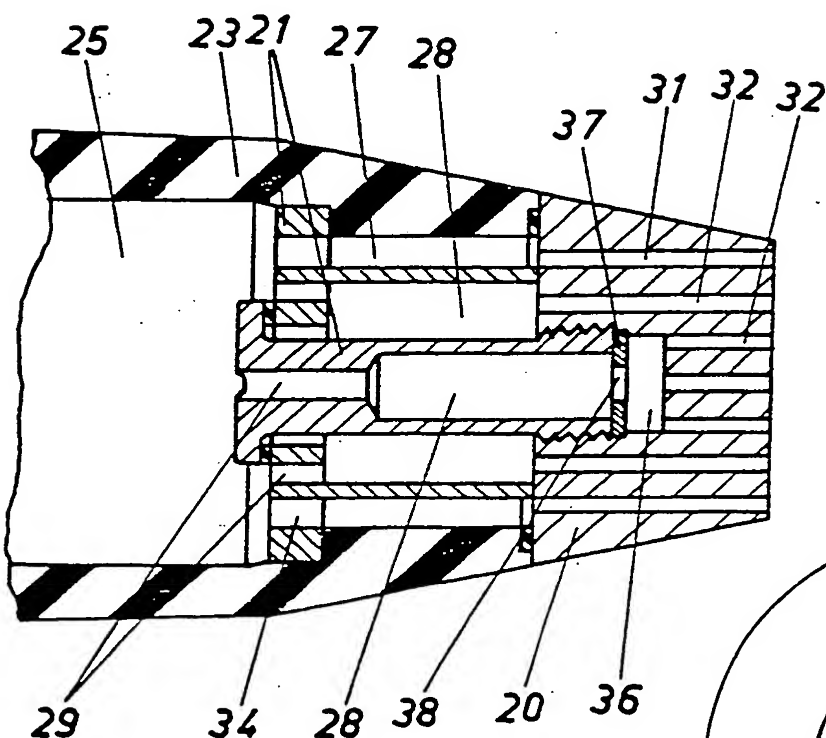
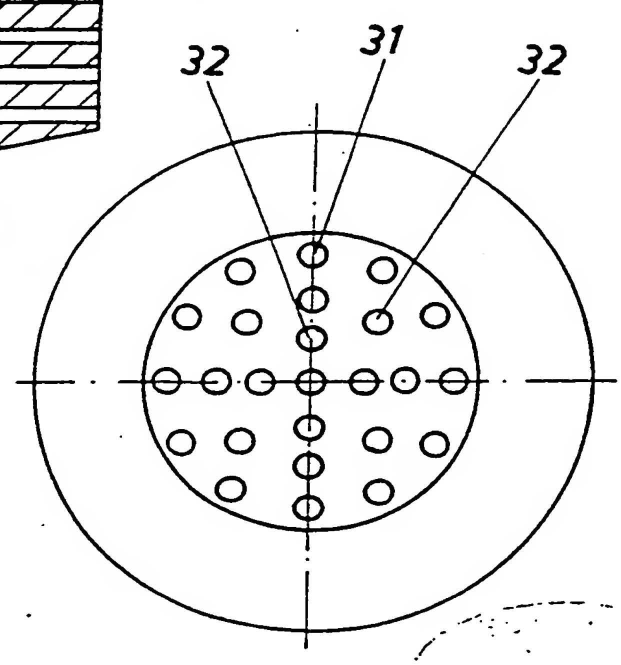


FIG 11



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE82/00373

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

B 05 B 1/14 // B 08 B 5/02

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	B 05 B 1/02,/06,/14-/18,/30,/32
US Cl	239:291

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 3 790 085 (AYER) 5 February 1974	
A	US, A, 4 013 227 (HERRERA) 22 March 1977	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
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